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Burning Index as a Partial Guide to Air Patrol in the South

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INTRODUCTION

Aircraft patrols are used for many fire control purposes in the South. A major use is in checking out individual smokes to determine whether or not suppression action by ground units is needed. Air patrols are almost indispensable in scouting and reporting the progress of large fires. During periods when tower lookouts are handicapped by low ground visibility, they are valuable as primary detectors. Also, they have been found effective in various aspects of fire prevention and law enforcement. It seems certain that increasing use will be made of air patrols because of their speed and versatility.

A fire control manager has the problem of deciding how much flying time he can afford and when and where he can buy the most protection for his money. Ordinarily there are few guidelines to help him. He must therefore weigh, as best he can, such factors as fire danger, visibility, activity of fire starters, season of year, values at stake, and the location of blind areas and hot spots, against the amount of flying time at his disposal. However, if accurate records for several years on the effectiveness of air patrol under different conditions were available, probability figures could be developed that would serve as guides to action.

The main purpose of this paper is to illustrate a method for analyzing certain records that should eventually provide useful operational information. The analysis deals only with number of fires, their time of occurrence, and their relation to burning index on the 8-100-0 fire danger meter now used extensively throughout the South.[1/] Other factors that might indicate the need for air patrol, such as visibility, expected increase in risk, and prevention activities, were not considered because information was not available. However, other things being equal, it seems that air patrols should be made at times when the probability of fire occurrence is the greatest. The analysis is based on that assumption.

Records for the analysis were obtained by the Southern Forest Fire Laboratory through a cooperative project with the Georgia Forestry Commission and the Georgia Forest Research Council. Preliminary tabulations were made by personnel stationed at the Laboratory.

1/ For a description of the 8-100-0 meter and its use see: How to Measure Forest Fire Danger in the Southeast by Ralph M. Nelson. U. S. Forest Serv. Southeast. Forest Expt. Sta. Paper 52, 22 pp. 1955.

ANALYSIS PROCEDURE AND RESULTS

For purposes of fire protection, the Georgia Forestry Commission has divided the State into 10 districts, as indicated in figure 1. As of January 1959, 97 fire danger stations were operated by the Commission in counties under protection. To insure the best possible danger records for analysis purposes, 3 to 6 key stations were selected in each of the districts. These 40 key stations were given special attention and were operated yearlong which permitted the derivation of an average burning index for each district for each day of the year.

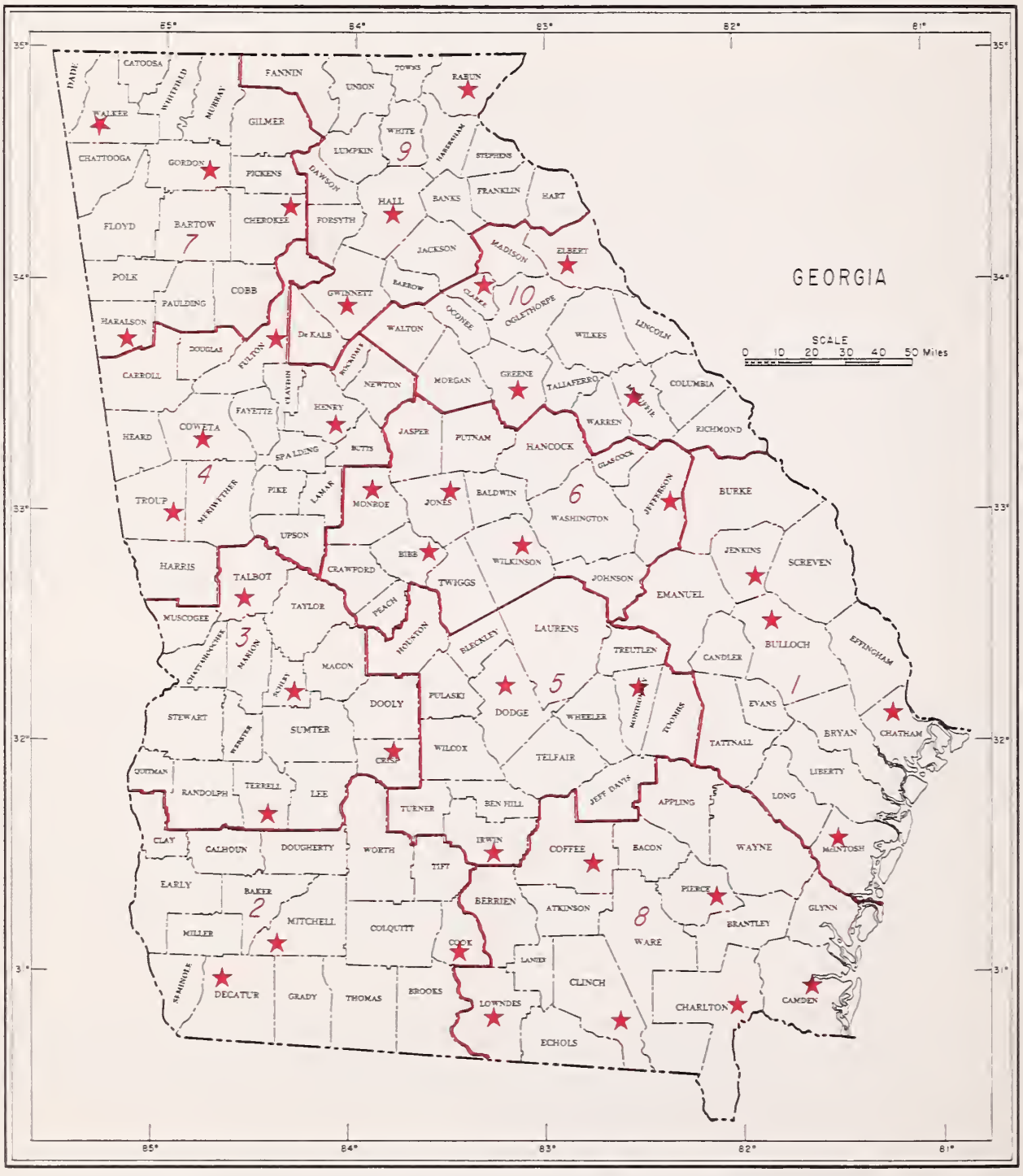

Figure 1. --Location of key fire danger stations and districts.

Fire Occurrence and Fire Danger

The first step in the analysis was to determine the degree of relationship between number of fires and burning index for the State as a whole. This was done by summing the number of days and fires in the 10 districts by each division of the burning index scale (tables 1 and 2). The number of fires was then divided by the number of days for each burning index division to obtain an average rate per day. These rates are plotted in figure 2. As will be seen, the number of fires per day increased as the burning index increased. The points for burning indexes 35, 40, and 45 were not plotted because they were based on so few days as to have little meaning.

Table 1.--Distribution of days by burning index and districts, Georgia, 1959

Burning index	Districts										State total
	1	2	3	4	5	6	7	8	9	10	
	Number										
1	147	147	150	160	155	147	153	138	129	126	1,452
2	62	43	44	54	52	47	68	65	54	68	557
3	26	27	24	36	24	33	30	23	34	25	282
4	15	24	22	21	19	25	18	17	23	32	216
5	20	16	16	17	12	20	14	12	18	22	167
6	13	17	19	10	15	19	10	15	8	12	138
7	15	10	10	12	12	9	9	15	10	8	110
8	10	11	11	9	13	11	6	10	17	12	110
9	8	6	8	7	7	6	8	6	8	4	68
10	4	8	10	6	8	2	8	10	11	9	76
11	7	6	2	5	7	6	3	9	4	4	53
12	6	5	6	3	6	8	4	4	7	10	59
13	8	5	9	5	5	7	11	3	6	2	61
14	6	6	8	1	7	4	4	7	5	3	51
15	--	3	3	--	5	--	2	4	3	4	24
16	3	6	6	3	4	2	2	5	4	7	42
17	2	2	3	3	4	6	--	4	5	1	30
20	7	7	4	6	5	7	6	8	5	5	60
25	5	11	8	5	2	3	5	7	10	6	62
30	1	3	2	2	3	2	2	1	3	3	22
35	--	2	--	--	--	--	1	2	--	1	6
40	--	--	--	--	--	1	--	--	1	1	3
45	--	--	--	--	--	--	1	--	--	--	1
Total	365	365	365	365	365	365	365	365	365	365	3,650

For those who are accustomed to think of fire danger in terms of class day, as indicated on the 8-100-0 meter, rather than units of burning index, the data were rearranged in table 3 by class day and grouped months. January, February, March, April, and December were combined because by far the greater number of fires occurred during these months. Regardless of fire season, there was a pronounced increase in number of fires per class day as measured danger increased. For example, during 1959 in Georgia, there were about 8 times as many fires on each class 4 day as on each class 2 day. Statements have occasionally been heard that more fires occurred on class 2 days than on class 4 days in certain areas. However, when figures were checked, we invariably found that there were also many more class 2 than class 4 days.

Table 2. --Distribution of fires by burning index and districts, Georgia, 1959

Burning index	Districts										State total
	1	2	3	4	5	6	7	8	9	10	
	Number										
1	30	17	16	46	38	27	32	64	8	14	292
2	34	11	23	56	35	27	71	108	17	35	417
3	35	16	12	62	23	40	35	40	16	10	289
4	43	54	26	66	20	47	39	14	24	35	368
5	79	59	15	47	17	26	36	29	24	23	355
6	76	74	26	56	35	44	30	32	13	10	396
7	75	21	27	66	25	28	51	52	17	9	371
8	52	39	23	42	34	28	28	18	24	19	307
9	41	43	23	45	21	9	38	22	12	8	262
10	24	25	35	32	25	3	64	34	31	12	285
11	42	29	6	47	23	12	21	43	4	6	233
12	70	49	15	31	19	29	22	33	34	31	333
13	37	20	20	57	28	25	88	3	18	2	298
14	36	12	20	4	20	18	35	45	27	7	224
15	--	4	8	--	37	--	20	8	35	9	121
16	5	34	27	42	30	9	32	10	5	17	211
17	9	8	14	51	9	15	--	42	39	5	192
20	121	24	9	84	34	30	98	58	24	9	491
25	30	38	67	87	11	12	106	35	114	22	522
30	29	4	15	58	63	15	75	3	52	24	338
35	--	2	--	--	--	--	21	20	--	1	44
40	--	--	--	--	--	16	--	--	18	12	46
45	--	--	--	--	--	--	27	--	--	--	27
Total	868	583	427	979	547	460	969	713	556	320	6,422

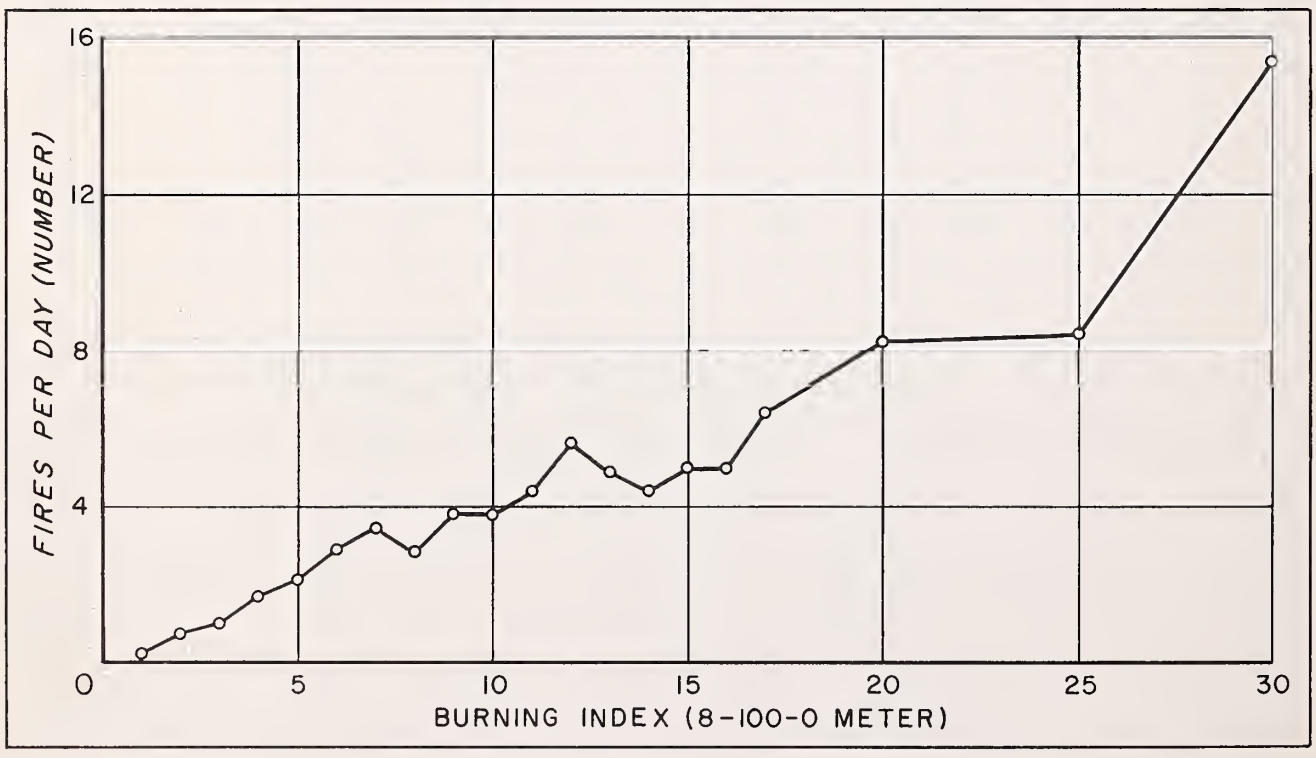

Figure 2. --Number of fires per day by burning index, Georgia, 1959.

Table 3. --Fires per danger class day by periods, Georgia, 1959

Class day (8-100-0 meter)	Burning index range	Jan., Feb., Mar., Apr., Dec.			May through Nov.			All months		
		Fires	Days	Fires per day	Fires	Days	Fires per day	Fires	Days	Fires per day
		Number								
1	1	46	308	0.15	273	1,144	0.24	319	1,452	0.22
2	2 to 5	754	442	1.7	652	780	0.84	1,406	1,222	1.2
3	6 to 17	2,773	615	4.5	460	207	2.2	3,233	822	3.9
4	20 to 45	1,421	145	9.8	43	9	4.8	1,464	154	9.5
Total		4,994	1,510		1,428	2,140		6,422	3,650	

As an incidental point, the positive relation described between number of fires and burning index does not always hold throughout the entire range of burning index. Exceptions are found in areas where there are relatively few fires or when there is abnormal activity by fire starters. Unfortunately, no one yet has been able to explain the vagaries of incendiarists or careless people so that the effect of risk can be taken into account.

The substance of the previous paragraphs is that there were a number of days with certain burning indexes in 1959 during which air patrol would have been more effective than on other days, considering only number of fires that occurred. This will be further explained in following sections.

Time of Fire Origin

A next step in the analysis was to group all fires by reported time of origin. From figure 3 it is clear that for the State as a whole, most fires (71 percent) started between noon and 5 p.m. Because of possible differences among districts, data were regrouped in table 4. Although some differences are apparent, there was fairly close agreement as to percent of fires that originated during specific periods of the day in the 10 districts. Again based solely on the number of fires that occurred, the most effective flying period was between noon and 5 p.m. This is on the assumption that pilot and observer can patrol for 5 hours without undue fatigue.

Relation of Days and Fires to Burning Index

Computations for District 2 (table 5) will illustrate the procedure used in relating number of days and fires to burning index. It was selected for no particular reason except that it held approximately a median position among districts with respect to number of fires in 1959. Only January through April, and December, were used in the calculations because a large proportion of all fires in the State occurred during these months. The number varied by districts, ranging from 64.5 to 88.1 percent of the year's total.

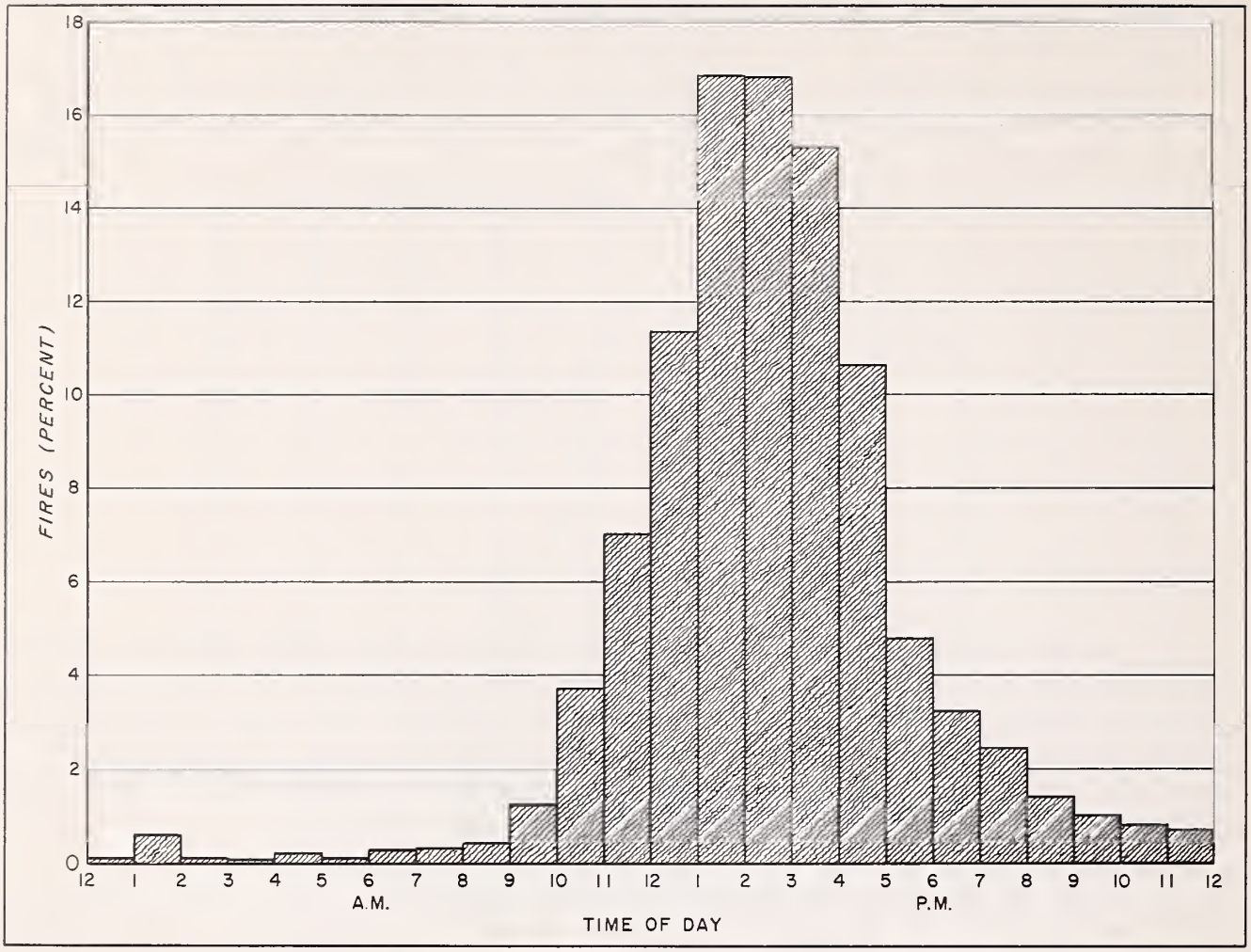

Figure 3. --Fires by hour of origin, Georgia, 1959.

Table 4. --Percent of fires by periods of origin and districts, Georgia, 1959

	Districts										State
	1	2	3	4	5	6	7	8	9	10	
	Percent										
Worst 4 hr. period											
12 noon-4 p.m.	55			63			59		60		60
1 p.m. -5 p.m.		66	62		64	63		65		60	
Worst 5 hr. period											
11 a.m.-4 p.m.	66										
12 noon -5 p.m.		76	72	73	74	75	69	73	70	71	71
Worst 6 hr. period											
11 a.m.-5 p.m.	73	81	79	79	79	82	76	79		81	78
12 noon -6 p.m.									78		

Table 5. --Relation of days and fires to burning index for the period January through April, and December. District 2, Georgia, 1959

Burning index	Days	Days cumulated	Days	Fires	Fires cumulated	Fires	Fires adjusted
	(1) Number	(2) Number	(3) Percent	(4) Number	(5) Number	(6) Percent	(7) Percent
1	26	151	100	8	509	100	76
2	8	125	83	3	501	98	74
3	9	117	77	11	498	98	74
4	12	108	72	47	487	96	73
5	11	96	64	52	440	86	65
6	11	85	56	66	388	76	58
7	7	74	49	20	322	63	48
8	9	67	44	34	302	59	45
9	4	58	38	42	268	53	40
10	4	54	36	18	226	44	33
11	5	50	33	27	208	41	31
12	5	45	30	49	181	36	27
13	3	40	26	15	132	26	20
14	4	37	25	8	117	23	17
15	2	33	22	3	109	21	16
16	6	31	21	34	106	21	16
17	2	25	17	8	72	14	11
20	7	23	15	24	64	13	10
25	11	16	11	34	40	8	6
30	3	5	3	4	6	1	1
35	2	2	1	2	2	0.4	0.3

First, days were tabulated by burning index, column 1, table 5. Next, the days were cumulated upwards in column 2, and percents calculated in column 3. The values in columns 2 and 3 mean, for example, that 74 days or 49 percent had burning indexes of 7 or more. A similar tabulation of fires was made in columns 4 to 6. However, because 76 percent of the fires (table 4) in District 2 occurred during the assumed 5-hour patrol period, noon to 5 p. m., each value in column 6 was multiplied by 0.76 to give the values in column 7. The figures in this last column mean, for example, that 48 percent of the total number of fires occurred during the 5-hour period on days having a burning index of 7 or more.

Major results of this study are summarized in table 6. In examining the table, it must be kept in mind that the values in it are based on the 5 months having highest fire occurrence, January through April, and December, and on a maximum of 5 hours flying time on any one day. More or fewer months or hours could, of course, have been used but the analysis procedure would have been the same.

Table 6 can best be explained by examining a few paired figures in it. For example, in District 1 had air patrols been made on half the days (50 percent column), flying would have been done on all days having a burning index of 5 or more during which time 58 percent of the fires occurred. Following along to the 100-percent column, it will be seen that had patrols been made on all days there would have been a gain of only 8 percent in number of fires.

Table 6. --Relation between percent of patrol days, percent of fires, and burning index, by districts, Georgia, 1959

District	Percent of patrol days																			
	10		20		30		40		50		60		70		80		90		100	
	BI[1/]	Fires	BI	Fires	BI	Fires	BI	Fires	BI	Fires	BI	Fires	BI	Fires	BI	Fires	BI	Fires	BI	Fires
		Percent		Percent		Percent		Percent		Percent		Percent		Percent		Percent		Percent		Percent
1	18	16	12	28	8	38	7	47	5	58	4	60	3	64	2	65	2	65	1	66
2	25	6	16	16	12	27	9	41	7	50	5	62	4	73	2	74	2	75	1	76
3	17	22	13	37	10	44	8	53	7	62	5	66	3	71	2	72	1	72	1	72
4	17	26	11	45	8	53	6	62	5	66	3	70	3	72	2	72	1	73	1	73
5	16	22	13	39	10	49	8	56	7	62	6	68	4	72	2	73	2	73	1	74
6	18	19	13	32	9	42	7	47	6	52	4	65	3	74	2	74	1	74	1	75
7	17	29	12	43	9	52	7	59	5	64	4	67	3	68	2	69	1	69	1	70
8	22	14	14	30	11	44	8	51	7	59	6	64	4	69	2	72	2	72	1	73
9	22	28	16	44	11	53	9	58	6	63	4	67	3	68	2	69	1	70	1	70
10	21	20	14	32	11	45	8	53	6	58	5	63	4	68	2	70	1	70	1	71
State	20	20	13	33	10	44	7	50	6	60	5	64	3	69	2	70	1	70	1	71

1/ BI = Burning Index.

Photo by Georgia Forestry Commission

Georgia Forestry Commission aircraft checks fire area. Twenty small planes fly reconnaissance, augmenting the fire tower network in locating and identifying fires. They are especially useful in checking out smokes to determine whether action by ground forces is necessary.

Photo by Georgia Forestry Commission

Aircraft can operate from Georgia's secondary road system, thus acting as eyes for the fire boss. Here the pilot has been called down for consultation with the fire crew to help coordinate the attack plan. He will go back aloft to scout out hot spots and runs and also act as lead plane for the fire-retardant bomber.

In table 6, a pair of values have been underscored for each district which appear to the writer, from inspection, to represent approximately the point of diminishing return. When these pairs are compared, remarkably little difference is seen: the burning index ranges from 4 to 6 units for all districts, and fires from 63 to 68 percent if District 1 is excluded. In short, it seems that air patrol would have been most effective on days with a burning index of 5 or more which would have required flying on 50 to 60 percent of the days. At the risk of excessive repetition, it is emphasized that "effective" refers only to periods of greatest fire occurrence.

Records for one year, such as analyzed in this report, obviously are inadequate for operational guidance. Furthermore, 1959 was a relatively easy fire year in Georgia. More information must be collected and organized in addition to such records as are discussed in this paper before the soundest planning basis for air patrol can be developed. The following are several of the more obvious kinds of information needed:

1. Under what visibility conditions is air patrol needed to supplement fixed detectors to meet detection requirements for a specific area?

2. On the basis of performance records, how much time is saved by ground forces as a result of air scouting of fires that do not require suppression action?

3. During periods of generally low fire occurrence, such as in summer, what is the maximum coverage that can be obtained with air patrol that will meet detection requirements and at what saving in lookout tower operation?

If several years of accurate records were available, some specific guidelines for air patrol could be developed to supplement the fire control manager's judgment. Estimates of probable burning index for the most dangerous part of the day could be obtained from a late morning danger measurement and the fire-weather forecast. These could be interpreted in terms of probability of fire occurrence. When combined with a check of visibility conditions and an estimate of the probability of change in risk, a fairly distinct picture of the fire situation should emerge. The fire control manager should then be able to reach a sounder decision as to the desirability of air patrol on a given day than if he had to rely on experience alone.

SUMMARY

Procedures for analyzing fire and fire danger records for use as partial guides to air patrol have been described. Based only on the relation of burning index to fire occurrence for the State of Georgia in 1959, it appears that:

1. Air patrol would have been most effective on days having a burning index of 5 or more.

2. The most effective flying period would have been between noon and 5 p. m.

3. Patrol would have been required on 60 percent of the days.

4. A little less than two-thirds of the fires occurred during the days and hours stated above.

Similar values are given for each of the ten protection districts in the State. There was relatively little difference among them.

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